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Neutrino Storage Ring Developments

presented by,

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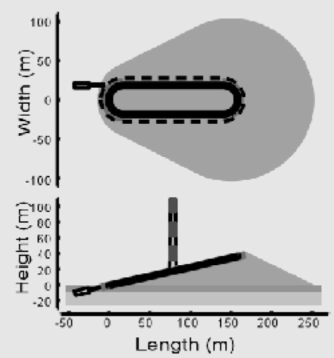
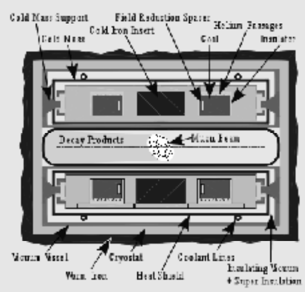
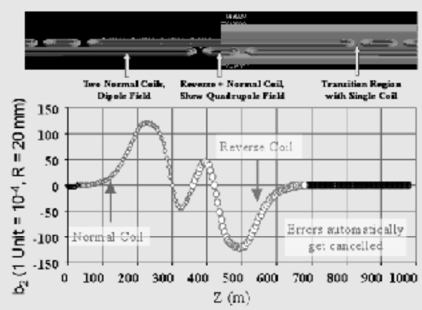


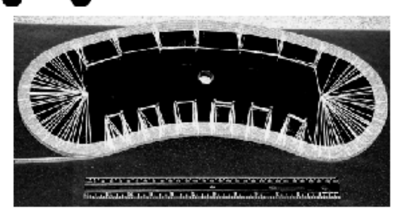




Some Muon Storage Ring Design Principles and Requirements.

Must keep the ring compact (*tilt* -> Δh).

- **For shortest arc use a large guide field.**
  - Go beyond NbTi, but then must work with brittle materials (Nb_3Sn or HTS).
  - The arc dipoles have significant sagitta.
  - Flat racetrack coils are conductor friendly.

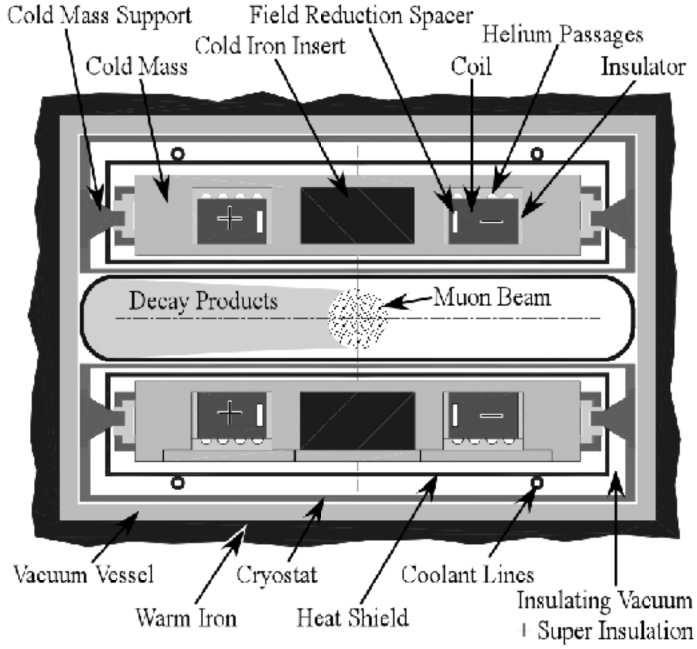


- **"Minimize aperture" with short cell length.**
  - Poor muon ε means keeping β and dispersion low as possible.
  - But avoid wasting space with many dipole/quadrupole coil ends.

- **1/3 beam energy goes into decay electrons.**

Muon Storage Ring Dipole Magnet Cross Section.

- Has simple racetrack coils and an open midplane.
- The large bend radius allows "react and wind."
- Warm iron yoke minimizes the cold mass.
- The decay products clear the superconducting coils.



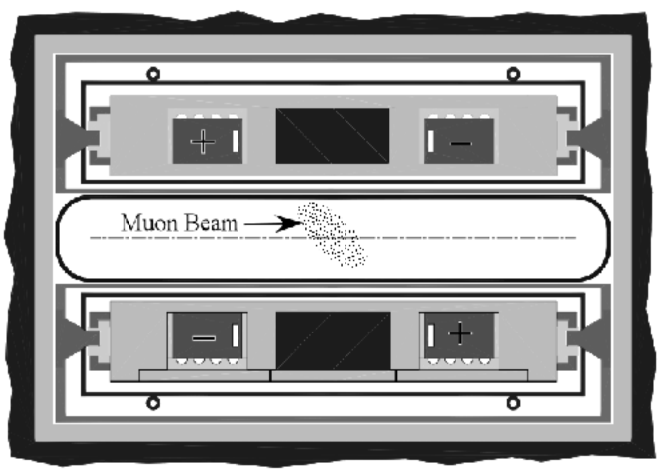
Muon Storage Ring Quadrupole Magnet Cross Section (Skew).

- The same construction as dipole.
- Do skew optics for decoupled motion in A–B eigenplanes.
- Follow standard prescription for dispersion matching and chromaticity correction.
- Can however get slightly more acceptance than from upright lattice, $\beta_{eff} = (\beta_A + \beta_B)/2$.

$X = (A+B)/\sqrt{2}$ $Y = (A-B)/\sqrt{2}$

$A = (X+Y)/\sqrt{2}$ $B = (X-Y)/\sqrt{2}$

Reverse polarity of one dipole coil to make a skew quadrupole.



Muon Storage Ring Magnet Coil Layout and Harmonic Cancelation.

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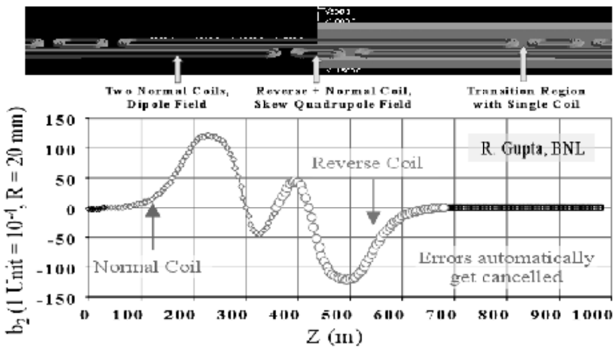
- **Overlap coils for dipole or skew quad.**
- **No wasted space at coil ends (transition).**
- **Automatic cancelation of end harmonics.**



For estimated errors at right a 20 mm reference radius is used. $\langle b_n \rangle$ and $\langle a_n \rangle$ are the expected means to the normal and skew terms. $d(b_n)$ and $d(a_n)$ are systematic uncertainties arising from design and manufacturing errors, and $\sigma(b_n)$ and $\sigma(a_n)$ are the random uncertainties in those values. Note that n = 2 corresponds to a sextupole term.

Dipole Error Summary*

n	$\langle b_n \rangle$	$d(b_n)$	$\sigma(b_n)$	$\langle a_n \rangle$	$d(a_n)$	$\sigma(a_n)$
1	0	0.2	0.2	0	1	2
2	1	1	2	0	0.1	0.5
3	0	0.1	0.1	0	0.3	1
4	-1	1	1	0	0.05	0.2
5	0	0.03	0.03	0	0.1	0.5
6	0.3	0.2	0.1	0	0.03	0.1
7	0	0.03	0.01	0	0.03	0.1
8	-0.1	0.1	0.02	0	0.03	0.1
9	0	0.03	0.01	0	0.03	0.1
10	-0.03	0.02	0.02	0	0.03	0.1

Skew Quadrupole Error Summary*

n	$\langle b_n \rangle$	$d(b_n)$	$\sigma(b_n)$	$\langle a_n \rangle$	$d(a_n)$	$\sigma(a_n)$
1	0	0.2	0.2	0	1	2
2	-0.5	0.5	1	0	1	0.5
3	0	0.1	0.1	2	2	1
4	0.5	0.5	0.5	0	0.05	0.2
5	0	0.03	0.03	1	1	2
6	0	0.2	0.1	0	0.03	0.1
7	0	0.03	0.01	0.5	0.5	0.3
8	0	0.1	0.05	0	0.03	0.1
9	0	0.03	0.01	0.1	0.03	0.1
10	0	0.02	0.01	0	0.03	0.1

*Errors given in units, 1 unit = 10^{-4} field deviation.

Muon Storage Ring Arc Optics and Magnet Design Parameters.

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$B = 6.93$ T, $L_D = 1.89$ m

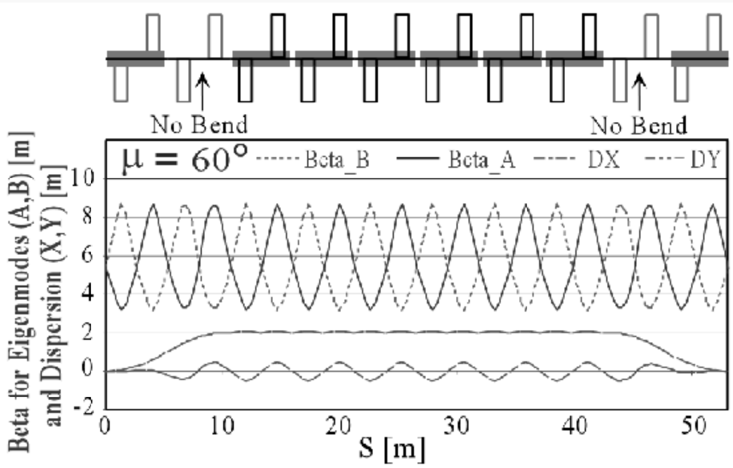
$G = 35$ T/m, $L_{SQ} = 0.76$ m

$L_{cell} = 5.3$ m

$L_{arc} = 10 \times L_{cell}$

$L_{straight} = 126$ m

$$\text{Decay Ratio} = \frac{126}{2(126+53)} = 35\%$$



- **The 163 m total length for ring is compatible with BNL site.**
- **Arcs are made up from three cryogenic sections (have conventional iron dominated quadrupoles elsewhere).**
- **Inject into up straight; ν down straight points at detector.**
- **There is no need for ultrahigh beam vacuum (insulating ok).**

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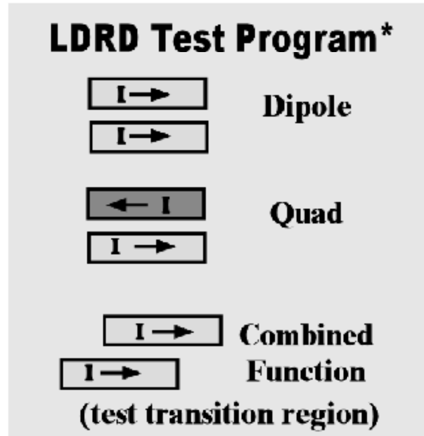
The Muon Storage Ring Model Magnet Test Program (LDRD).

Want to test practical aspects for making a magnet:

- Make support structure to handle coil forces (heat leak).
- Work through coil winding, handling and the assembly into a coldmass.
- Test in many different configurations (dipole, skew quadrupole and skew combined function).
  - **Make Nb_3Sn coil of same size as the muon storage ring magnet small coil.**
  - **Design and construct cold mass side supports.**
  - **Estimate heat leak and verify coil performance in all configurations.**



*With two coil packs can change polarity and shift to test different magnet configurations.

Cut away view of storage ring arc lattice.